

are strongly degraded to the violet; the best exposed shows strongly alternating intensities; hence it is certainly due to nitrogen or to ionized nitrogen. It has the appearance of a single branch whose spacing rapidly increases towards shorter wave-lengths. These bands appear not to have been observed before.

A more complete investigation of the α -X system is proposed in the near future using a large vacuum spectrograph.

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Deposition of Chromium on Glass

R. Ritschl¹ has perfected a simple apparatus with which a uniform half-silvering can be done on Fabry-Perot interferometer plates. The film is put on by evaporation of silver from a hot tungsten filament in a vacuum; the silver having been tied to the tungsten with platinum.

The writer has extended this process to chromium, with an idea to its use for astronomical reflectors. As is well known, the present silver-on-glass surfaces tarnish quickly, and do not reflect a usable fraction of incident light beyond 3350Å. To remedy this defect, other metals have been deposited by evaporation, but chromium seems to excel in reflectivity and permanence. The chromium

was electroplated about a millimeter thick on a tungsten filament and was evaporated *in vacuo* very quickly. The resultant surface is firm, and can be dissolved only by HCl. The reflectivity of a test surface has been determined as: 60 percent at 4200Å; 68 percent at 3450Å; and 62 percent at 2900Å. The adaptation of the process to large surfaces is now in progress.

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¹ *Half-Silvering Interferometer Plates*, Zeits. f. Physik **69**, 578–585 (1931).

Note on Molecular Structure

Hund¹ and Mulliken² in recent papers have considered the structure of polyatomic molecules, treating each electron as if it moved in a wave function which was a solution of a problem of many centers—a molecular orbital, as Mulliken happily names such a function. The writer³ and Pauling⁴ on the other hand have treated the same problem from a starting point in which each electron moves as in a single atom, or as Mulliken would say in an atomic orbital. It is the purpose of this note to point out the relation between the two methods. This has already been done to some extent in a paper on metallic cohesion;⁵ there the method used by Hund and Mulliken has an analogue in the treatment of Sommerfeld and Bloch, whereas the other method, used by Pauling, the present writer, Heitler and London, resembles more closely Heisenberg's treatment of ferromagnetism. In that paper, the connections between the two methods were brought out, and it was shown that if treated in the proper way both methods necessarily led to the same answer, so that a choice between them must be made on the basis of convenience rather than correctness. Essentially the same situation holds in the molecular case.

A first simple calculation by either method will be incorrect, and it is necessary to go to a considerable refinement to secure good results. First we shall describe these refinements necessary in the method of Pauling and the writer. One can start by assuming covalent bonds, and taking these bonds to be located between definite pairs of atoms. Then the writer has shown how to set up wave functions, correctly taking account of antisymmetry and of spin, describing this situation. But now to improve this we must (1) take account of other possible ways of drawing the valence bonds. This can be considered in one way as the correct perturbation treatment for spin degeneracy. Or it can be considered as taking account of *shared valence*, a common phenomenon, and the one which Mulliken

¹ F. Hund, Zeits. f. Physik **73**, 1 (1931); **73**, 565; **74**, 1 (1932).

² R. S. Mulliken, Phys. Rev. **41**, 49 (1932). I am indebted to Professor Mulliken for sending me a copy of the latter paper before publication.

³ J. C. Slater, Phys. Rev. **38**, 1109 (1931).

⁴ Linus Pauling, Journ. Am. Chem. Soc. **53**, 1367 (1931).

⁵ J. C. Slater, Phys. Rev. **35**, 509 (1930).